PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION OF ELECTION

(PCT Rule 61.2)

To:

Commissioner
US Department of Commerce
United States Patent and Trademark
Office, PCT
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CP2/5C24
Arlington, VA 22202
ETATS-UNIS D'AMERIQUE

in its capacity as elected Office

Date of mailing (day/month/year) 12 February 2001 (12.02.01)	
International application No. PCT/GB00/02274	**Applicant's or agent's file reference** MCM/PJ/21303
International filing date (day/month/year) 12 June 2000 (12.06.00)	**Priority date** (day/month/year) 10 June 1999 (10.06.99)
Applicant LANGLEY, Richard, Jonathan	

1. The designated Office is hereby notified of its election made:

[X] in the demand filed with the International Preliminary Examining Authority on:

10 January 2001 (10.01.01)

[ ] in a notice effecting later election filed with the International Bureau on:

2. The election [X] was

[ ] was not

made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

The International Bureau of WIPO **34, chemin des Colombettes** **1211 Geneva 20, Switzerland**	Authorized officer Olivia TEFY
Facsimile No.: (41-22) 740.14.35	Telephone No.: (41-22) 338.83.38

WO 00/77884
PCT/GB00/02274

PATENT COOPERATION TREATY

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From the INTERNATIONAL BUREAU

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NOTICE INFORMING THE APPLICANT OF THE COMMUNICATION OF THE INTERNATIONAL APPLICATION TO THE DESIGNATED OFFICE

(PCT Rule 47.1(c), first sentence)

Date of mailing (day/month/year): 21 December 2000 (21.12.00)	
Applicant's or agent's file reference: MCM/PJ/21303	IMPORTANT NOTICE
International application No.: PCT/GB00/02274	International filing date (day/month/year): 12 June 2000 (12.06.00) — Priority date (day/month/year): 10 June 1999 (10.06.99)
Applicant: HARADA INDUSTRIES (EUROPE) LIMITED et al	

1. Notice is hereby given that the International Bureau has communicated, as provided in Article 20, the International application to the following designated Offices on the date indicated above as the date of mailing of this Notice:

   AG,AU,DZ,KP,KR,MZ,US

   In accordance with Rule 47.1(c), third sentence, those Offices will accept the present Notice as conclusive evidence that the communication of the international application has duly taken place on the date of mailing indicated above and no copy of the international application is required to be furnished by the applicant to the designated Office(s).

2. The following designated Offices have waived the requirement for such a communication at this time:

   AE,AL,AM,AP,AT,AZ,BA,BB,BG,BR,BY,CA,CH,CN,CU,CZ,DE,DK,EA,EE,EP,ES,FI,GB,GD,GE,GH, GM,HR,HU,ID,IL,IN,IS,JP,KE,KG,KZ,LC,LK,LR,LS,LT,LU,LV,MD,MG,MK,MN,MW,MX,NO,NZ,OA, PL,PT,RO,RU,SD,SE,SG,SI,SK,SL,TJ,TM,TR,TT,TZ,UA,UG,UZ,VN,YU,ZA,ZW

   The communication will be made to those Offices only upon their request. Furthermore, those Offices do not require the applicant to furnish a copy of the international application (Rule 49.1(a-bis)).

3. Enclosed with this Notice is a copy of the international application as published by the International Bureau on

   21 December 2000 (21.12.00) under No. WO 00/77884

REMINDER REGARDING CHAPTER II (Article 31(2)(a) and Rule 54.2)

If the applicant wishes to postpone entry into the national phase until 30 months (or later in some Offices) from the priority date, a demand for international preliminary examination must be filed with the competent International Preliminary Examining Authority before the expiration of 19 months from the priority date.

It is the applicant's sole responsibility to monitor the 19-month time limit.

Note that only an applicant who is a national or resident of a PCT Contracting State which is bound by Chapter II has the right to file a demand for international preliminary examination.

REMINDER REGARDING ENTRY INTO THE NATIONAL PHASE (Article 22 or 39(1))

If the applicant wishes to proceed with the international application in the national phase, he must, within 20 months or 30 months, or later in some Offices, perform the acts referred to therein before each designated or elected Office.

For further important information on the time limits and acts to be performed for entering the national phase, see the Annex to Form PCT/IB/301 (Notification of Receipt of Record Copy) and Volume II of the PCT Applicant's Guide.

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Form PCT/IB/308 (July 1998)

PATENT COOPERATION TREA

From the INTERNATIONAL BUREAU

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NOTIFICATION CONCERNING SUBMISSION OR TRANSMITTAL OF PRIORITY DOCUMENT

(PCT Administrative Instructions, Section 411)

To:

MOIR, Michael, Christopher
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100 Gray's Inn Road
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Date of mailing (day/month/year) 11 October 2000 (11.10.00)	
Applicant's or agent's file reference MCM/PJ/21303	**IMPORTANT NOTIFICATION**
International application No. PCT/GB00/02274	International filing date (day/month/year) 12 June 2000 (12.06.00)
International publication date (day/month/year) Not yet published	Priority date (day/month/year) 10 June 1999 (10.06.99)
Applicant HARADA INDUSTRIES (EUROPE) LIMITED et al	

1. The applicant is hereby notified of the date of receipt (except where the letters "NR" appear in the right-hand column) by the International Bureau of the priority document(s) relating to the earlier application(s) indicated below. Unless otherwise indicated by an asterisk appearing next to a date of receipt, or by the letters "NR", in the right-hand column, the priority document concerned was submitted or transmitted to the International Bureau in compliance with Rule 17.1(a) or (b).

2. This updates and replaces any previously issued notification concerning submission or transmittal of priority documents.

3. An asterisk(*) appearing next to a date of receipt, in the right-hand column, denotes a priority document submitted or transmitted to the International Bureau but not in compliance with Rule 17.1(a) or (b). In such a case, the attention of the applicant is directed to Rule 17.1(c) which provides that no designated Office may disregard the priority claim concerned before giving the applicant an opportunity, upon entry into the national phase, to furnish the priority document within a time limit which is reasonable under the circumstances.

4. The letters "NR" appearing in the right-hand column denote a priority document which was not received by the International Bureau or which the applicant did not request the receiving Office to prepare and transmit to the International Bureau, as provided by Rule 17.1(a) or (b), respectively. In such a case, the attention of the applicant is directed to Rule 17.1(c) which provides that no designated Office may disregard the priority claim concerned before giving the applicant an opportunity, upon entry into the national phase, to furnish the priority document within a time limit which is reasonable under the circumstances.

Priority date	Priority application No.	Country or regional Office or PCT receiving Office	Date of receipt of priority document
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REPLY DATE
DIARY ENTERED

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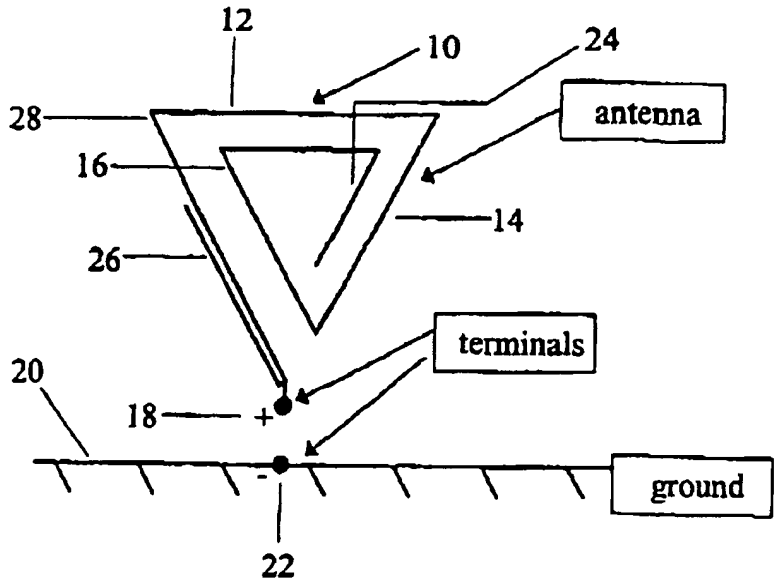

(57) Abstract: An RF antenna comprises a single conductor arranged in a generally spiral triangular form, and means for connecting the conductor to an antenna feed at or adjacent one end of the spiral, the other end of the spiral being open-circuited.

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MULTIBAND ANTENNA

This invention relates to antennas, particularly but not exclusively for installation in cars or other vehicles.

With the increasing amount of media broadcasting including the new digital audio broadcasting (DAB) there is an increased need for a single antenna system to cover all bands. Ideally a system for an on car antenna should be small, low cost and unobtrusive. For most automobile communication systems a standard wire mast antenna or whip antenna is used but this is obtrusive on a car and susceptible to damage. Additional band requirements could lead to additional obtrusive antennas.

A printed or wire antenna being low profile is a good alternative and can be mounted conformally. One such form of antenna is disclosed in Helical and Spiral Antennas by Hisamatsu Nakano (Research Studies Press Ltd. 1987). Chapter II describes a two-wire square spiral antenna in which two arms of the spiral extend outwards from a feed at the centre of the spiral. This antenna radiates when the circumference of the spiral is about two wavelengths, the resultant radiation usually being circularly polarised.

The present invention adopts a completely different approach, namely a single-wire polygonal spiral whose radiating frequency bands are related to the overall length of the wire and the proximity of the successive turns of the spiral to each other. Although discussed for convenience in the context of a transmitting antenna, the invention of course applies equally to an antenna used in a receiving mode.

According to the invention there is provided a RF antenna comprising a single conductor arranged in polygonal spiral form, and means for connecting the conductor to an antenna feed at or adjacent one end of the conductor, the other end of the conductor being open-circuited, the polygonal spiral form comprising successive linear sections each forming an angle with a succeeding or preceding one, the total length of the conductor and the spacing of adjacent co-extending sections being such that the antenna exhibits resonances in a plurality of frequency bands.

Preferably, the length of the sections and the angles between them are such that the antenna is linearly polarised.

Preferably, opposite sides of the generally spiral form comprises at least three major sides which are markedly non-parallel with each other.

The invention may further be described as a RF antenna comprising a single conductor arranged in a generally spiral form, and means for connecting the conductor to an antenna feed at or adjacent one end of the conductor, the other end of the conductor being open-circuited, wherein the envelope of the generally spiral form comprises three, four or five major sides which are markedly non-parallel with each other, the total length of the conductor and the spacing of adjacent co-extending sections being such that the antenna exhibits resonances in a plurality of frequency bands.

The invention may still further be described as a RF antenna comprising a single conductor arranged in a generally spiral form, and means for connecting the conductor to an antenna feed at or adjacent one end of the conductor, the other end of the conductor being open-circuited, the envelope of the spiral form comprising three major sides disposed so as to lie in a triangular relationship, the total length of the conductor and the spacing of adjacent co-extending sections being such that the antenna exhibits resonances in a plurality of frequency bands. Preferably the one end is the outer end.

An end of each major side may merge with an end of an adjoining major side. The lengths and angles between the major sides may be such that the antenna is linearly polarised.

It will be appreciated that the spiral need not be strictly planar; for example the antenna can be conformed to a slightly curved surface such as a vehicle window or body panel. Indeed, especially if the antenna is mounted in a concealed location, it could be markedly non-planar eg. in the form of a helical spiral, provided that the functional requirements are achieved.

The aspect ratio of an overall envelope of the spiral form may be chosen such that the antenna has a required ratio of longitudinal and vertical polarisation. The overall envelope

of the spiral form may be substantially in the shape of an equiangular triangle. Alternatively, it may be in the shape of an isosceles triangle, and preferably, in use, a top side of the overall envelope of the spiral is shorter than the other two sides of the overall envelope.

Co-extensive parts of the spiral form may extend parallel to each other. In a particular form of the antenna, when the antenna is disposed generally upright, from its one end the conductor may be adapted to extend upwardly at an angle, then generally horizontally, then generally downwardly at an angle to a point adjacent its one end, thereby forming a first outer side, a top outer side and a second outer side, respectively, and then to extend upwardly, horizontally and downwardly within the outer sides to form a first inner side, a top inner side and a second inner side, respectively. Preferably, the first and top inner sides are each approximately 0.8 as long as the respective first and top outer sides, and the spacing between the first outer side and first inner side and between the top outer side and the top inner side are each approximately 0.1 of the length of the first outer side. The second inner side may be approximately one-third the length of the second outer side.

By "generally co-extensive sections" is meant sections of the spiral form, which whilst not necessarily of the same length, extend generally alongside and preferably parallel to each other.

One end of the conductor may be an outer end of the spiral form.

The antenna may also also comprise a stub antenna extending from the one end of the conductor so as to be alongside an outermost portion of the spiral form, the stub antenna providing a required additional resonant frequency.

In the particular form of the antenna described above, the stub antenna preferably extends from the one end of the conductor so as to be alongside the first outer side and, more preferably, is approximately 0.4 the length of the first outer side. Even more preferably, the spacing of the stub antenna from the first outer side is approximately 0.1 the length of the stub antenna. In this configuration, the antenna has resonant frequencies at approximately 100 MHz and 220 MHz.

The antenna may be mounted on a substrate for attachment to a window or other surface.

The antenna may comprise a ground plane functionally adjacent the conductor.

Alternatively the antenna may be in combination with a further said antenna, the two antennas being arranged as a dipole.

The invention also provides a window or vehicle body panel or other vehicle fitment comprising an antenna as set forth above.

The window or panel may form a dielectric between the antenna and the ground plane.

In another aspect the invention provides a method of manufacturing an antenna, comprising disposing or defining a conductor in a polygonal spiral form with a feed connection at or adjacent one end thereof, selecting the spacing between adjacent co-extensive sections of the polygonal spiral form and/or an overall length of the conductor such that the antenna has a plurality of required resonant frequencies. Preferably, the length and angles between successive sections of the polygonal spiral form are selected such that the antenna has a required ratio of horizontal and vertical polarisation.

Preferred features of the present invention will now be described, by way of example only, with reference to the accompany drawings, in which:

Figure 1 illustrates a first embodiment of the antenna of the invention;

Figure 2 illustrates a second embodiment of the antenna of the invention;

Figure 3 is a more detailed view of the antenna of Figure 1;

Figure 4 illustrates a third embodiment of the antenna of the invention;

Figure 5 shows the frequency response of the antenna of Figure 3;

Figure 6 shows the frequency response of an antenna with conductor length of 110mm;

Figure 7 shows the polar radiation pattern of the antenna of Figure 3.

Figures 8 to 14 further illustrate the effects of varying the overall length of an equiangular triangular spiral antenna and varying the spacing of its turns.

Figures 15, 16 and 17 illustrate further possible shapes of an antenna according to the invention.

Figures 18 to 21 are drawings illustrating triangular antenna radiation polarisation.

Figure 1 shows the basic shape of one type of antenna according to the invention. It is in the form of a triangular spiral 10 in which the included angles between adjacent sides 12, 14 are equal (60°) ie. each turn of the spiral, and the overall envelope of the spiral, is substantially an equilangular triangle.

The spiral consists of a single length of wire having a terminal for connection at its outer end 18 to one conductor of a co-axial transmission line. The antenna is disposed adjacent a ground plane 20, which has a terminal 22 for connection to the other (shielding) conductor of the co-axial line. Alternatively, a coplanar pair or other suitable transmission line may be used.

The spiral 10 may conveniently be printed on or embodied in the rear or other window of a motor vehicle, by known techniques, the ground plane 20 being provided by an adjacent metal panel of the car body in which the window is fitted.

Thus, in particular, the roof of the vehicle can be utilised as the ground plane. With the increasing use of plastics or other non-metallic materials for vehicle body panels and bumpers (fenders) and other vehicle body fitments, it alternatively may be convenient to embody the antenna on or in one of these parts. The antenna could be provided as a wire enclosed in a flexible film for this purpose.

The lowest (fundamental) resonant frequency is determined by the overall length and number of turns of the spiral. Because the position of the outer end is determined by the terminal 18, the innermost side of the spiral 24 may be foreshortened, eg. in Figure 3. A further resonant frequency is attained from the spacing of the co-extensive corresponding parts of the spiral.

A stub antenna 26 is provided alongside and parallel to the outermost side 28 to provide another resonant frequency, as discussed below. Further stub antennas may be provided, preferably extending generally parallel to antenna 26 to provide yet further resonant frequencies in other bands. The resonant frequency of the stub antenna is determined primarily by its length, but may also be affected by reactive coupling to an adjacent portion of the antenna.

An alternative form of antenna is shown in Figure 2. Here, two triangular spirals 10 as already described are arranged relative to each other so as to form a dipole, the ground plane being dispensed with. The terminals 18, 20 preferably are connected to a balanced transmission line or to a twisted pair with balun, as known per se.

Referring to Figure 3, the dimensions of the spiral 10 of Figure 1 are given, as determined in a prototype which gives mixed polarisation coverage for the following bands:

AM (140-283KHz & 526-1607KHz)
FM European (88-108MHz) or Japan 76-90MHz)
DAB1 (217.5-230MHz)
DAB2 (1452-1492MHz)

Other frequency bands can be covered by choosing suitable dimensions for the structure, as discussed below. The antenna can incorporate an amplifier to give increased sensitivity at each band.

The side projection stub 26 provides matching at the higher frequency band (DAB2) and the remaining spiral geometry sets the lower frequency bands. The resonant frequencies of the triangular spiral can be changed by varying the values of h (the height of the antenna) and d (the conductor spacing). By varying the value of d the inductance between adjacent parts

of the antenna changes and hence the loading of the structure changes, thereby changing the effective electrical length of antenna. The overall length of the line constituting the spiral antenna also can be increased or decreased thus changing the operating band frequencies and the number of operating bands. The geometry may also change so that the number of turns on the spiral increases or decreases, depending on the overall length.

The spiral shown in Figure 3 has equal angles. If the angles are changed, hence changing the aspect ratio, for example as shown in Figure 4 so that the shape becomes akin to an isosceles rather than an equilangular triangle, then the ratio of vertical polarisation to horizontal polarisation power radiated will change. This is useful where mixed polarisation broadcasting is used such as FM radio and TV in the UK and provides easy adjustment with this type of antenna.

The synthesis of an antenna design from first principles is mathematically complicated, and design can with advantage be approached empirically. The main principles are as follows:

The overall length of conductor in the spiral determines the lowest operating frequency, hence a long antenna will operate at a lower frequency while a short antenna will operate at a higher frequency.

The stub 26 determines the frequency of the highest band - it resonates as a $\lambda/2$ monopole, modified by its proximity to the main conductor.

The gap between the adjacent turns or parts thereof affects several parameters. In effect the gap determines the mutual coupling between the conductors:

- a narrow gap leads to a shorter antenna;
- the gap width tunes the intermediate frequency band;
- the width of the gap determines the frequency bandwidth at the lower bands - increasing the gap increases the bandwidth;
- differential gaps can be set between the sides - in other words the gaps are not all equal between each arm - this allows adjustment of the bandwidths of different frequency bands;

horizontal to vertical polarisation ratio is determined by the lengths and selective angles of the major sides as discussed hereafter with regard to Figure 18.

Figure 5 plots the resonances of the antenna of figure 3. There are resonant frequency bands near 100MHz, 220MHz and 1470MHz. The AM band does not utilise a resonant structure. Figure 6 shows the effect of increasing the overall length from 65mm as in Figure 3 to 110mm. The number of resonances increases with new resonances at 370 and 480MHz, and the lowest frequency of resonance reduces to 40MHz.

Sensitivity (gain) tests show that the performance of the antenna is comparable with mast antennas. The bandwidth at all bands can be improved with an active matching circuit which can also provide gain and hence the possibility of improved sensitivity.

The radiation patterns in Figure 7 show the comparison between the triangular spiral antenna of Figure 3 mounted on the rear passenger side window of a car and a reference monopole mounted on the roof of the same car. The gain of the active spiral is higher than that of the monopole except for a null near 40° due to blocking by the c-pillar on the car. The pattern off-car is symmetrical and very similar to a monopole.

Figures 8 to 12 further illustrate the effects of varying the overall length of an equiangular triangular spiral antenna and the spacing of its turns. Each plot is of return loss (dB) against frequency (MHz) of an antenna configured as in Figure 8c. The return loss equates to the matching of the antenna VSWR, the deeper and wider the nulls (more negative on the plot), the better the matching and the bandwidth.

Figure 8a shows the return loss of an antenna having an overall length of 135mm, and a separation d of 10mm. Figure 8b shows the return loss for the same antenna with d increased to 15mm. This results in a deeper null at 95MHz, (ie. better matching of the resonance to the European FM broadcast band) and a slightly improved bandwidth. However the resonance 275MHz is much more dependent on the spacing d and is moved to about 220MHz, and is made much wider, resulting in better matching of the antenna to the DAB 1 band over a wider bandwidth.

The resonance for the European FM band can be maintained for varying antenna lengths by varying the spacing d. Increasing d with length can maintain this resonance at an approximately constant frequency, but the higher resonance at 200 + MHz moves, so this resonance effectively can be tuned. Thus, Figure 9 (length = 63mm, d = 3mm), Figure 10 (length = 100mm, d = 5mm), Figure 11 (length = 177mm d = 20mm) and Figure 12 (length = 195mm d = 25mm) and also Figure 8b (length = 135mm d = 15mm) show that an antenna for the European FM band (88-108 MHz) and the DAB 1 band (217.5-230 MHz) can be achieved with various combinations of antenna length and spacing. Thus there is considerable flexibility to tailor the antenna to the space available.

The FM band is approximately 3 metres wavelength. An antenna that has an approximate diameter of one-half wavelength will exhibit circular polarisation. The dimensions of the antenna shown in Figure 3 has a cross-dimension (one corner to the middle of an opposite side) that is much less than one-half wavelength, and thus this antenna has negligible circular polarisation.

Figures 13 and 14 illustrate still further the effects of varying the spacing between the turns of a triangular spiral antenna. Figure 13 illustrates the configuration of the antenna. It has a first outer side 100, a top outer side 101, a second outer side 102, first inner side 103, and top inner side 104. The first outer side 100 and first inner side 103 are parallel and spaced from each other by the gap "b". The top outer side 101 and top inner side 104 are parallel and spaced from each other by the gap "a". With the overall length of the antenna fixed and the gap "a" fixed at 10mm, gap "b" was varied between 5mm and 30mm to examine the effect on resonant frequency and bandwidth. The resultant tuning and bandwidth are shown in Figure 14.

From Figure 14 it can be seen that the frequency bands of interest are centred on 100MHz and 220MHz. At 100MHz, increasing gap "b" increases the resonant frequency. Increasing gap "b" significantly widens the band (bandwidth). At 220MHz, the resonant frequency is approximately constant. The width of the band (at -5dB on Figure 14) is affected only slightly by the size of gap "b".

Several variations based on the foregoing principles are evident. For example, the spiral may be in the form of a regular or irregular triangle (adjacent parts of each turn of the conductor remaining parallel) in which opposite sides are markedly non-parallel, or the spiral may be arranged in some other regular or irregular polygonal shape. An irregular quadrilateral spiral, for example, can behave similarly to a triangular one, especially if one side of the quadrilateral is much shorter than the others so that its overall envelope tapers sharply to one end, as shown in Figure 15. Regular polygons with six or more sides are unlikely to be effective, since they are approaching a circular outline, but a regular (Figure 16) or irregular polygon may have utility. For example, an irregular hexagon in which very short sides alternate with long ones results in a generally triangular envelope with the corners of the triangle 'chamfered-off', as shown in Figure 17. Such a configuration is effectively triangular and can be expected to behave as such. Effectively the three major sides 30, 32, 34 lie in a triangular relationship and are joined together and to the remainder of the spiral by intervening short sides 36, 38, 40. In contrast, in the triangular spiral of Figure 1 or the quadrilateral or pentagonal spirals of Figures 15 and 16 , each major side defining the envelope (42, 44, 46, 48 in Figure 15) has an end which merges with an end of an adjoining major side. The principle remains to determine resonant frequencies by adjusting the overall length, and/or the spacing of the adjacent parts of the conductor, and/or by adjusting the aspect ratio. Adjacent lengths of conductor should normally be generally parallel, although non-parallel configurations may be found advantageous in some cases eg. for control of bandwidth.

Still in accordance with the foregoing principles, the antenna feed may be at the inner end of the spiral rather than the end. In that case the stub antenna 26 also is arranged at the inner end of the spiral.

Figure 18 illustrates how relative horizontally and vertically polarised radiation can be adjusted. The figure shows an antenna having a triangular outer envelope and comprised of five connected linear sections '1' to '5' as shown. The radiation from the conductor is linear and the current decays as it travels along the arms so that it is strongest in arm 1 and weakest in arm 5. If the decay is linear, then on average arm 1 has 5 times the current of arm 5.

Figure 19 illustrates the currents in the five arms of the Figure 18 antenna resolved into horizontal and vertical vectors. The number under each of the vectors corresponds to the arm with the same number in Figure 18. Figure 20 illustrates the currents present if arm 5 is removed, and Figure 21 illustrates the currents present if both arms 4 and 5 are removed.

Thus the relative strengths of the polarised radiation can be changed. In this simple illustration the resonant frequencies also will change with the change in length and configuration of the antenna, but the principle of adjusting the radiation vectors can be applied together with the other design principles set out earlier, especially by changing the lengths and relative angles of the sections of the polygonal antenna.

Each feature disclosed in this specification (which term includes the claims) and/or shown in the drawings may be incorporated in the invention independently of other disclosed and/or illustrated features.

Statements in this specification of the objects or advantages of the invention relate to preferred embodiments of the invention, but not necessarily to all embodiments of the invention falling within the claims.

The text of the abstract filed herewith is repeated here as part of the specification.

A RF antenna comprises a single conductor arranged in a generally spiral triangular form, and means for connecting the conductor to an antenna feed at or adjacent one end of the spiral, the other end of the spiral being open-circuited.

CLAIMS:

1. A RF antenna comprising a single conductor arranged in polygonal spiral form, and means for connecting the conductor to an antenna feed at or adjacent one end of the conductor, the other end of the conductor being open-circuited, the polygonal spiral form comprising successive linear sections each forming an angle with a succeeding or preceding one, the total length of the conductor and the spacing of adjacent co-extending sections being such that the antenna exhibits resonances in a plurality of frequency bands.

2. An antenna as claimed in claim 1, wherein the lengths of the sections and the angles between them are such that the antenna is linearly polarised.

3. An antenna as in claim 1 or 2, wherein opposite sides of the generally spiral form comprises at least three major sides which are markedly non-parallel with each other.

4. A RF antenna comprising a single conductor arranged in a generally spiral form, and means for connecting the conductor to an antenna feed at or adjacent one end of the conductor, the other end of the conductor being open-circuited, wherein the envelope of the generally spiral form comprises three, four or five major sides which are markedly non-parallel with each other, the total length of the conductor and the spacing of adjacent co-extending sections being such that the antenna exhibits resonances in a plurality of frequency bands.

5. A RF antenna comprising a single conductor arranged in a generally spiral form, and means for connecting the conductor to an antenna feed at or adjacent one end of the conductor, the other end of the conductor being open-circuited, the envelope of the spiral form comprising three major sides disposed so as to lie in a triangular relationship, the total length of the conductor and the spacing of adjacent co-extending sections being such that the antenna exhibits resonances in a plurality of frequency bands.

6. An antenna as in any of claims 3, 4 or 5, wherein an end of each major side merges with an end of an adjoining major side.

7. An antenna as claimed in any of claims 3, 4 or 5, wherein the lengths and angles between the major sides are such that the antenna is linearly polarised.

8. An antenna as claimed in claim 7, wherein the aspect ratio of the overall envelope of the spiral form is chosen such that the antenna has a required ratio of horizontal and vertical polarization.

9. An antenna as claimed in any of claims 4 to 8, wherein an overall envelope of the spiral form is substantially in the shape of an equiangular triangle.

10. An antenna as claimed in any of claims 4 to 8, wherein an overall envelope of the spiral form is substantially in the shape of an isosceles triangle.

11. An antenna as claimed in claim 10, wherein, when the antenna is disposed generally upright, a top side of the overall envelope of the spiral form is shorter than the other two sides of the overall envelope.

12. An antenna as claimed in any preceding claim, wherein co-extensive parts of the spiral form extend generally parallel to each other.

13. An antenna as claimed in claim 9, wherein, when the antenna is disposed generally upright, from its one end the conductor is adapted to extend upwardly at an angle, then generally horizontally, then generally downwardly at an angle to a point adjacent its one end, thereby forming a first outer side, a top outer side and a second outer side, respectively, and then to extend upwardly, horizontally and downwardly within the outer sides to form a first inner side, a top inner side and a second inner side, respectively.

14. An antenna as claimed in claim 13, wherein the first and top inner sides are each approximately 0.8 as long as the respective first and top outer sides, and wherein the spacing between the first outer side and first inner side and between the top outer side and the top inner side are each approximately 0.1 of the length of the first outer side.

15. An antenna as claimed in claim 14, wherein the second inner side is approximately one-third the length of the second outer side.

16. An antenna as claimed in any preceding claim, wherein the one end of the conductor is an outer end of the spiral form.

17. An antenna as claimed in any preceding claim, and also comprising a stub antenna extending from the one end of the conductor so as to be alongside an outermost portion of the spiral form, the stub antenna providing a required additional resonant frequency.

18. An antenna as claimed in claim 13, 14 or 15, and also comprising a stub antenna extending from the one end of the conductor so as to be alongside the first outer side.

19. An antenna as claimed in claim 18, wherein the stub antenna is approximately 0.4 the length of the first outer side.

20. An antenna as claimed in claim 19, wherein the spacing of the stub antenna from the first outer side is approximately 0.1 the length of the stub antenna.

21. An antenna as claimed in claim 20, wherein the antenna has resonant frequencies at approximately 100 MHz and 220 MHz.

22. An antenna as claimed in any preceding claim, further comprising a ground plane functionally adjacent the conductor.

23. An antenna as claimed in any preceding claim, in combination with a further said antenna, the two antennas being arranged as a dipole.

24. An antenna as claimed in any preceding claim, mounted on a substrate for attachment to a window or other surface.

25. A window or vehicle body panel or other vehicle fitment comprising an antenna as claimed in any preceding claim.

26. A window or vehicle body panel or other vehicle fitment as claimed in claim 25, wherein the window or body panel forms a dielectric between the antenna and the ground plane.

27. A method of manufacturing an antenna, comprising disposing or defining a conductor in a polygonal spiral form with a feed connection at or adjacent one end thereof, selecting the spacing between adjacent co-extensive sections of the polygonal spiral form and/or an overall length of the conductor such that the antenna has a plurality of required resonant frequencies.

28. A method as claimed in claim 27 comprising selecting the length and angles between successive sections of the polygonal spiral form such that the antenna has a required ratio of horizontal and vertical polarisation.

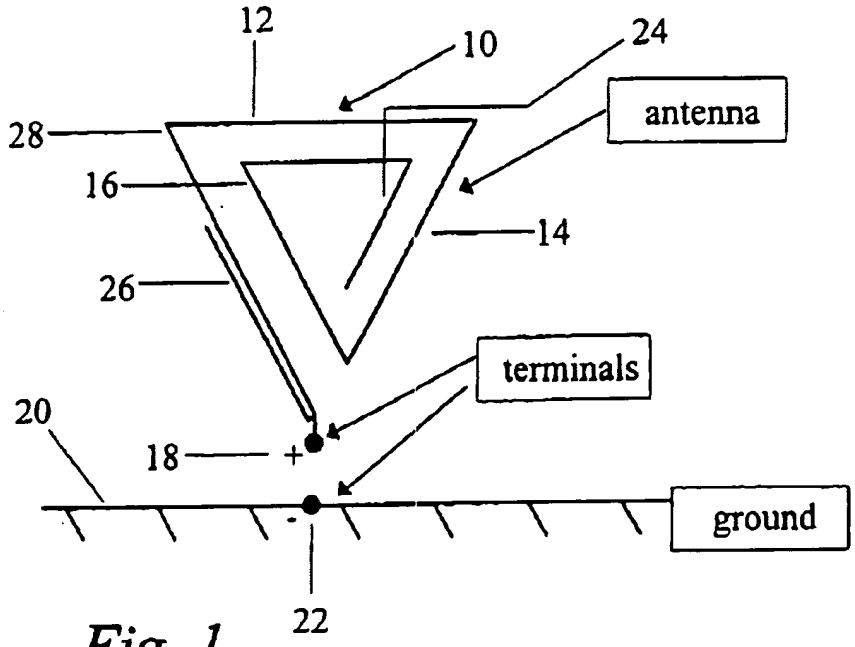
12
10
24
antenna
28
16
14
26
terminals
20
18
+
ground
-
22

Fig. 1

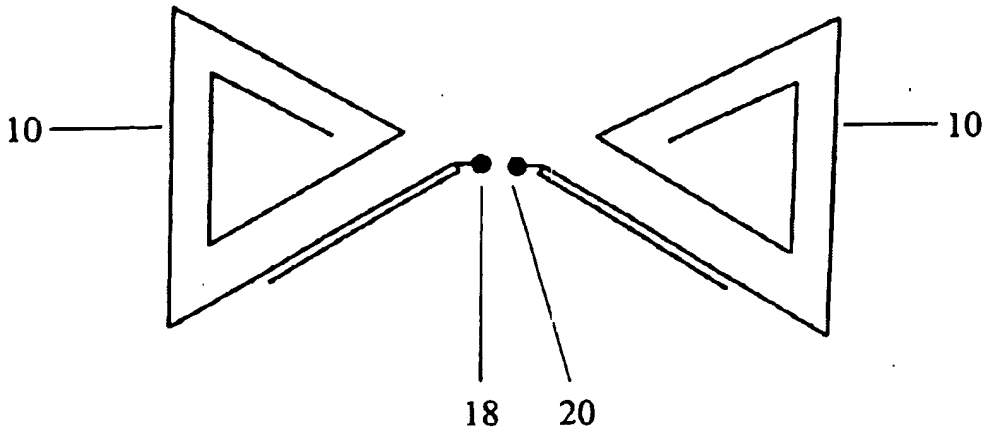
10
10
18
20

Fig. 2

WO 00/77884 PCT/GB00/02274

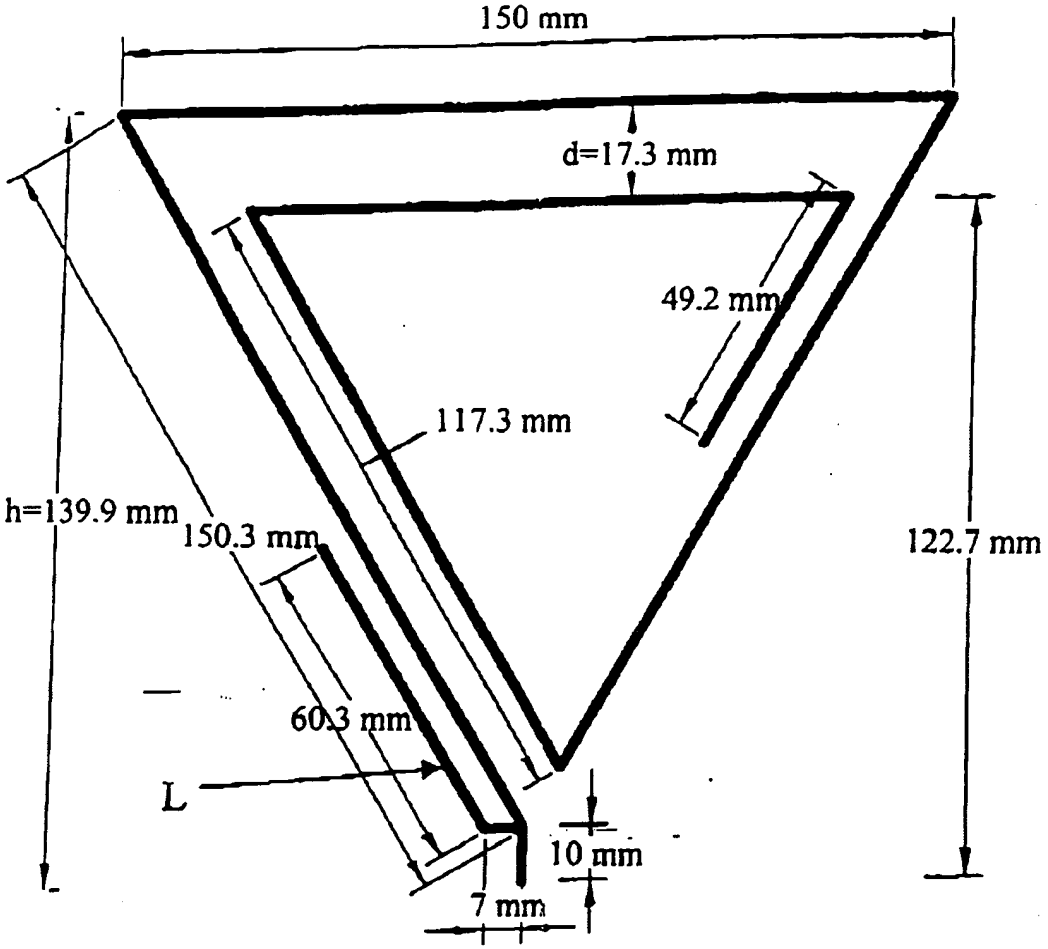

Fig. 3

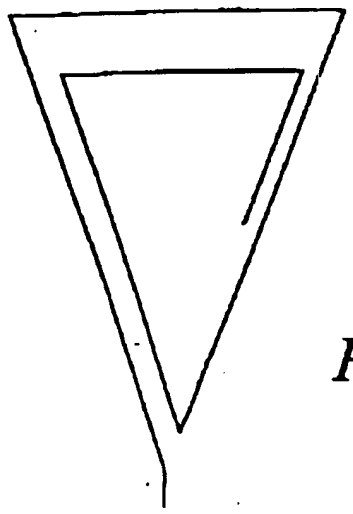

Fig. 4

WO 00/77884 10/018324 PCT/GB00/02274

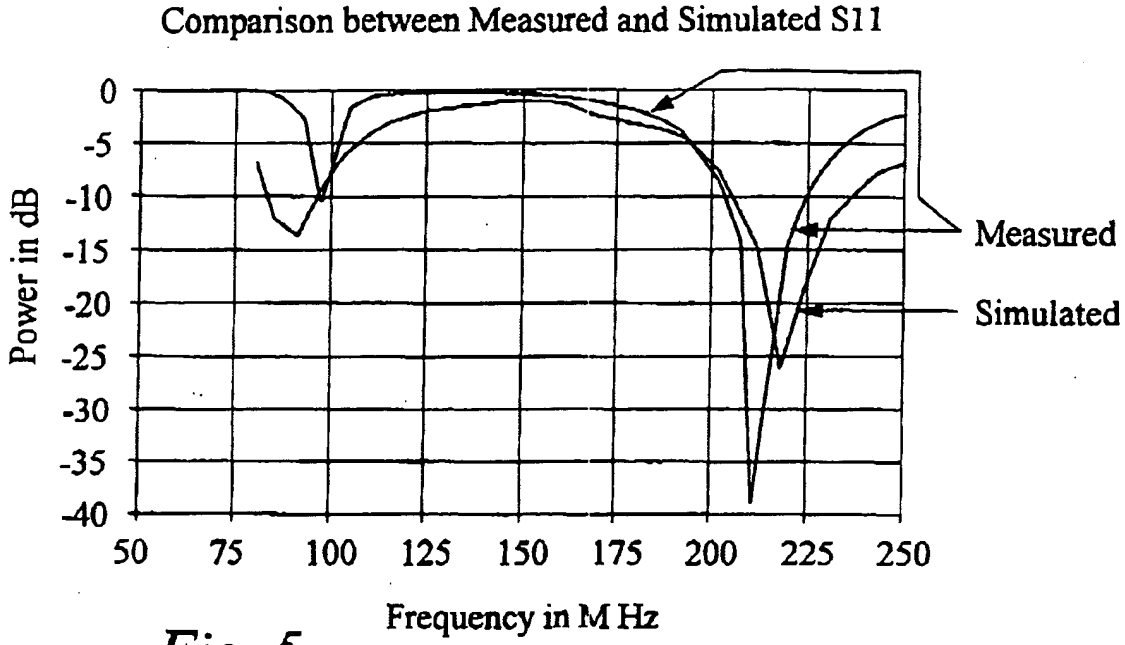

Fig. 5

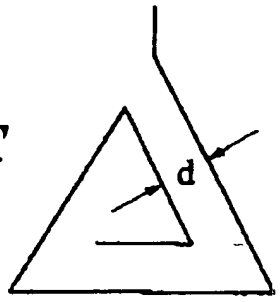

Fig. 8C

WO 00/77884 10/018324 PCT/GB00/02274

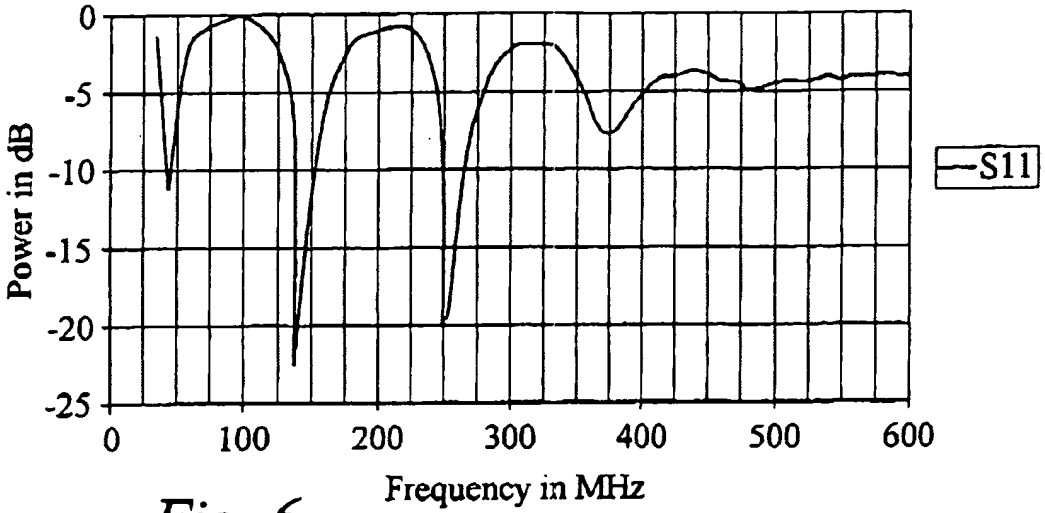

Fig. 6

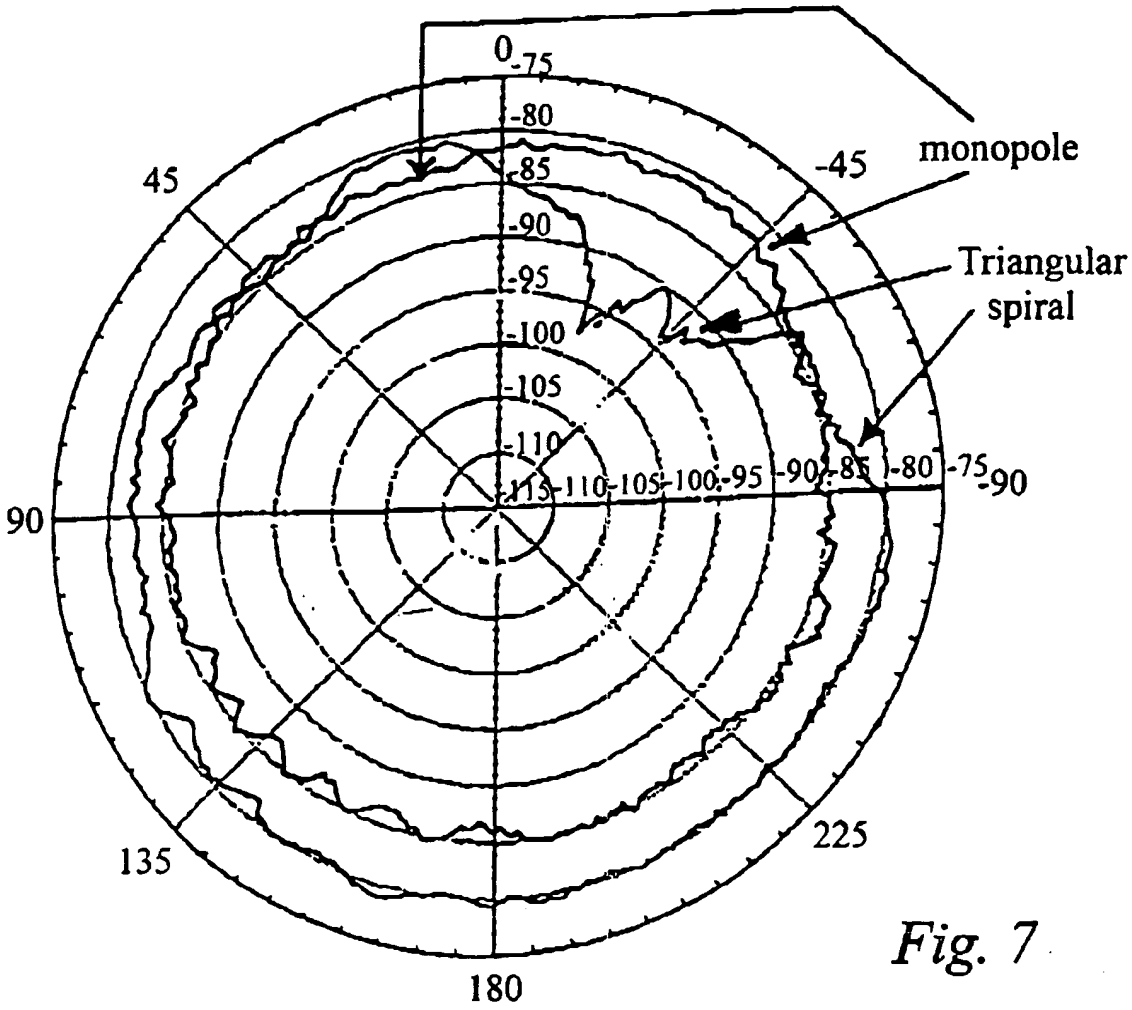

Fig. 7

WO 00/77884

10/018324
PCT/GB00/02274

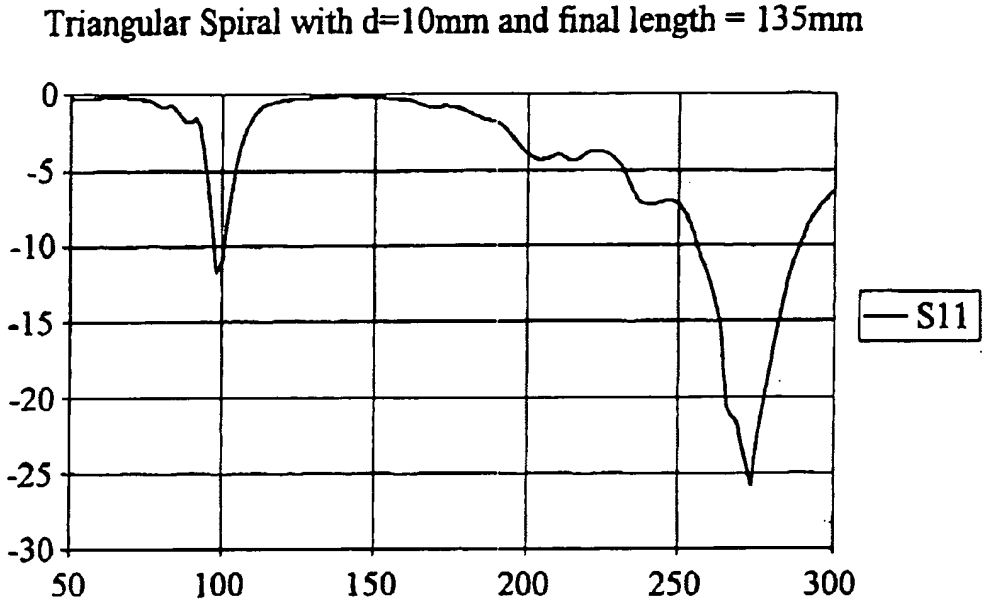

Fig. 8A

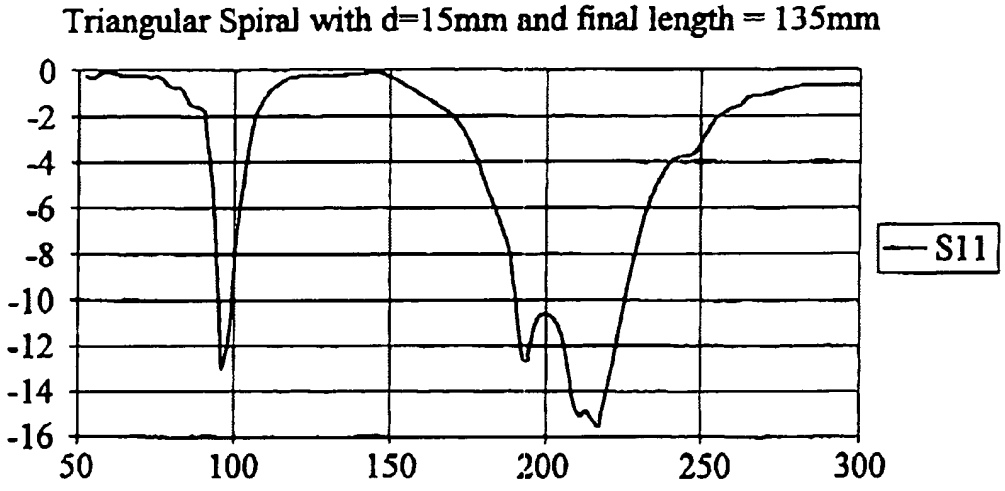

Fig. 8B

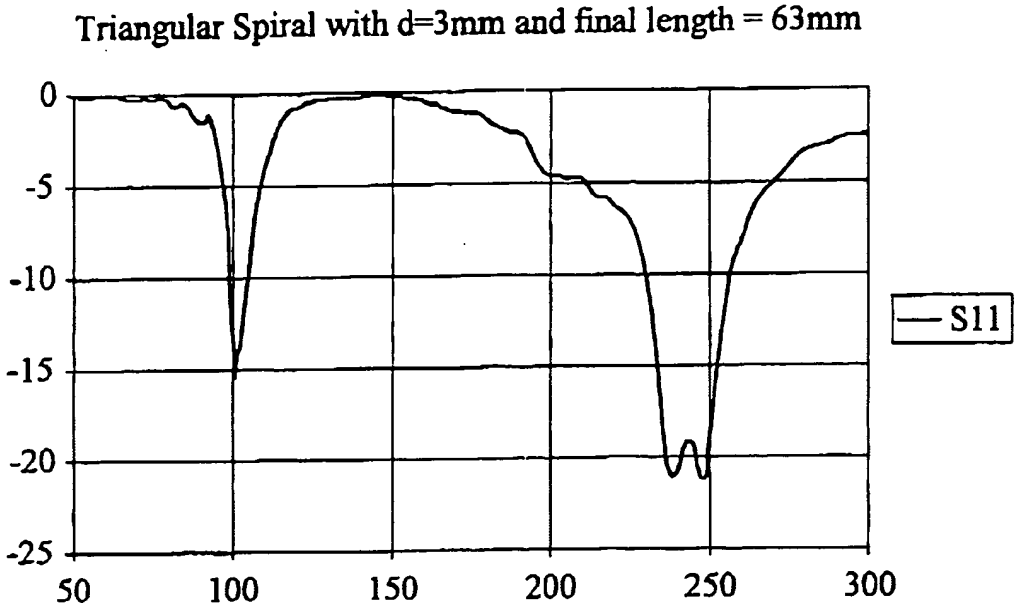
Triangular Spiral with d=3mm and final length = 63mm
0
-5
-10
-15
-20
-25
50
100
150
200
250
300
S11

Fig. 9

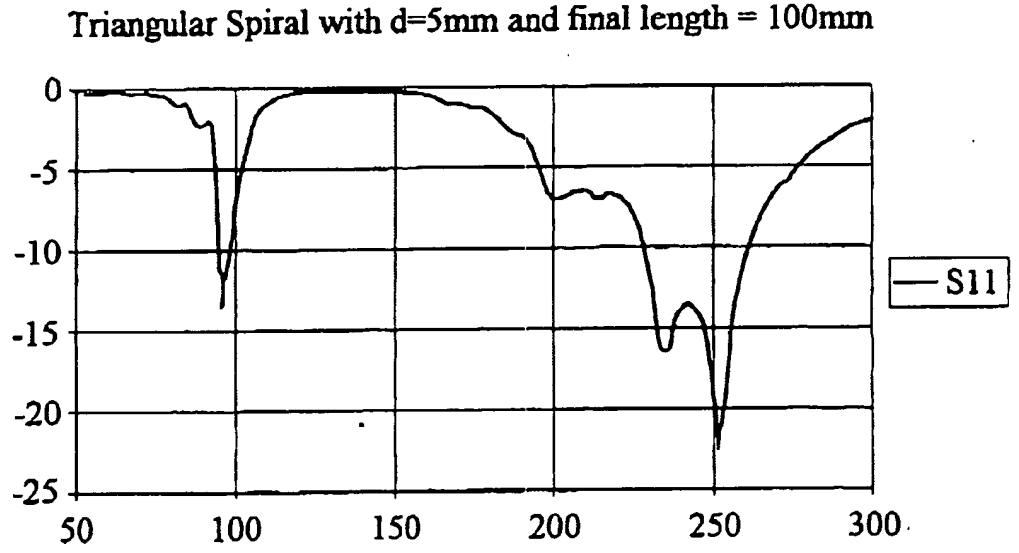
Triangular Spiral with d=5mm and final length = 100mm
0
-5
-10
-15
-20
-25
50
100
150
200
250
300
S11

Fig. 10

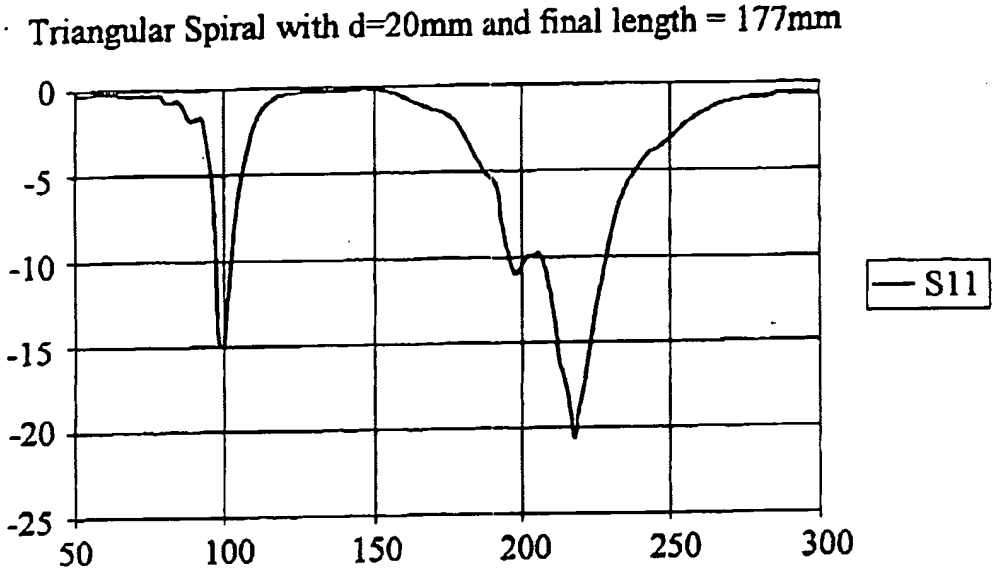
Triangular Spiral with d=20mm and final length = 177mm
0
-5
-10
-15
-20
-25
50
100
150
200
250
300
S11

Fig. 11

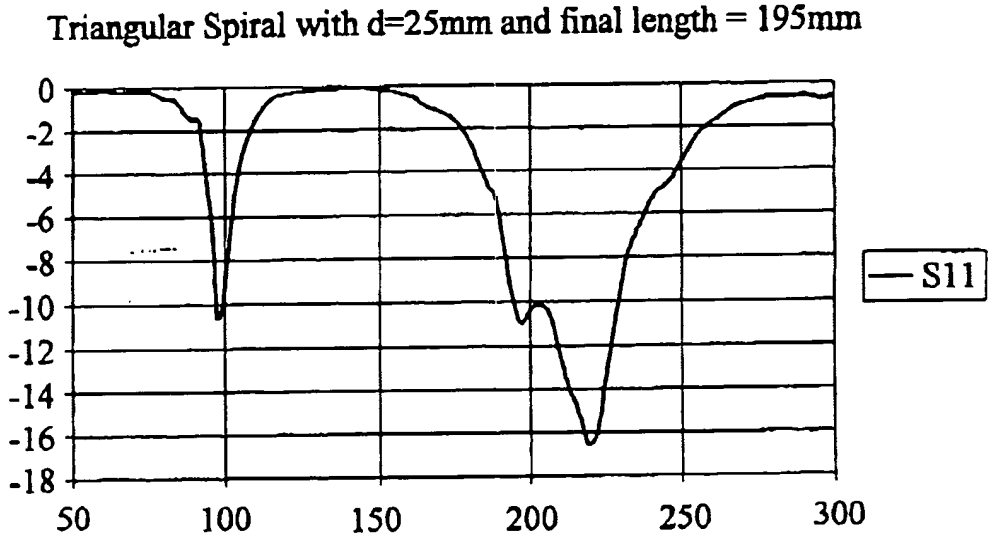
Triangular Spiral with d=25mm and final length = 195mm
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
50
100
150
200
250
300
S11

Fig. 12

WO 00/77884 10/018324 PCT/GB00/02274

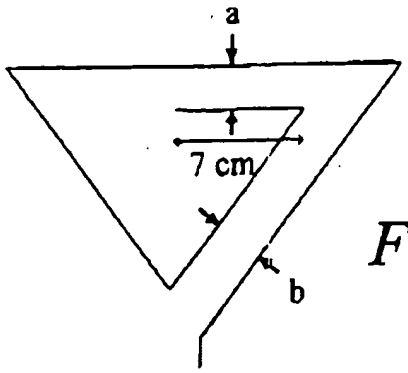

Fig. 13

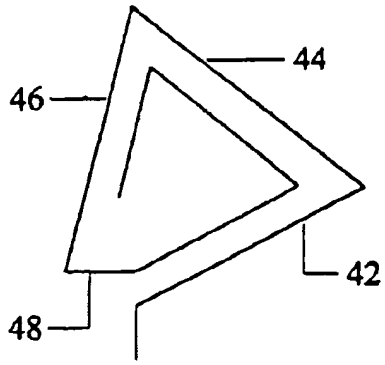

Fig. 15

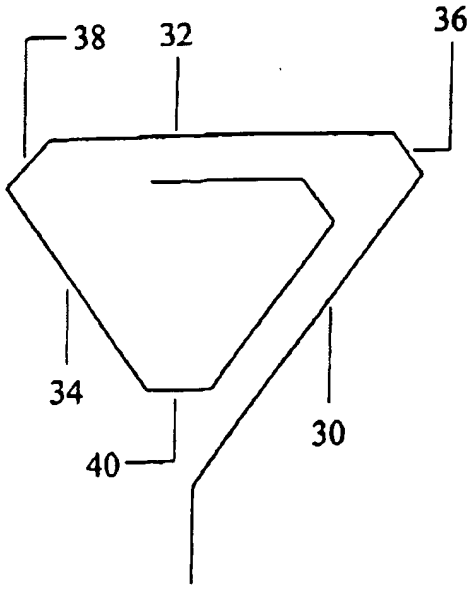

Fig. 17

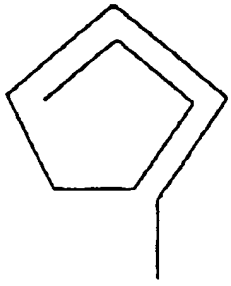

Fig. 16

WO 00/77884 PCT/GB00/02274 10/018324

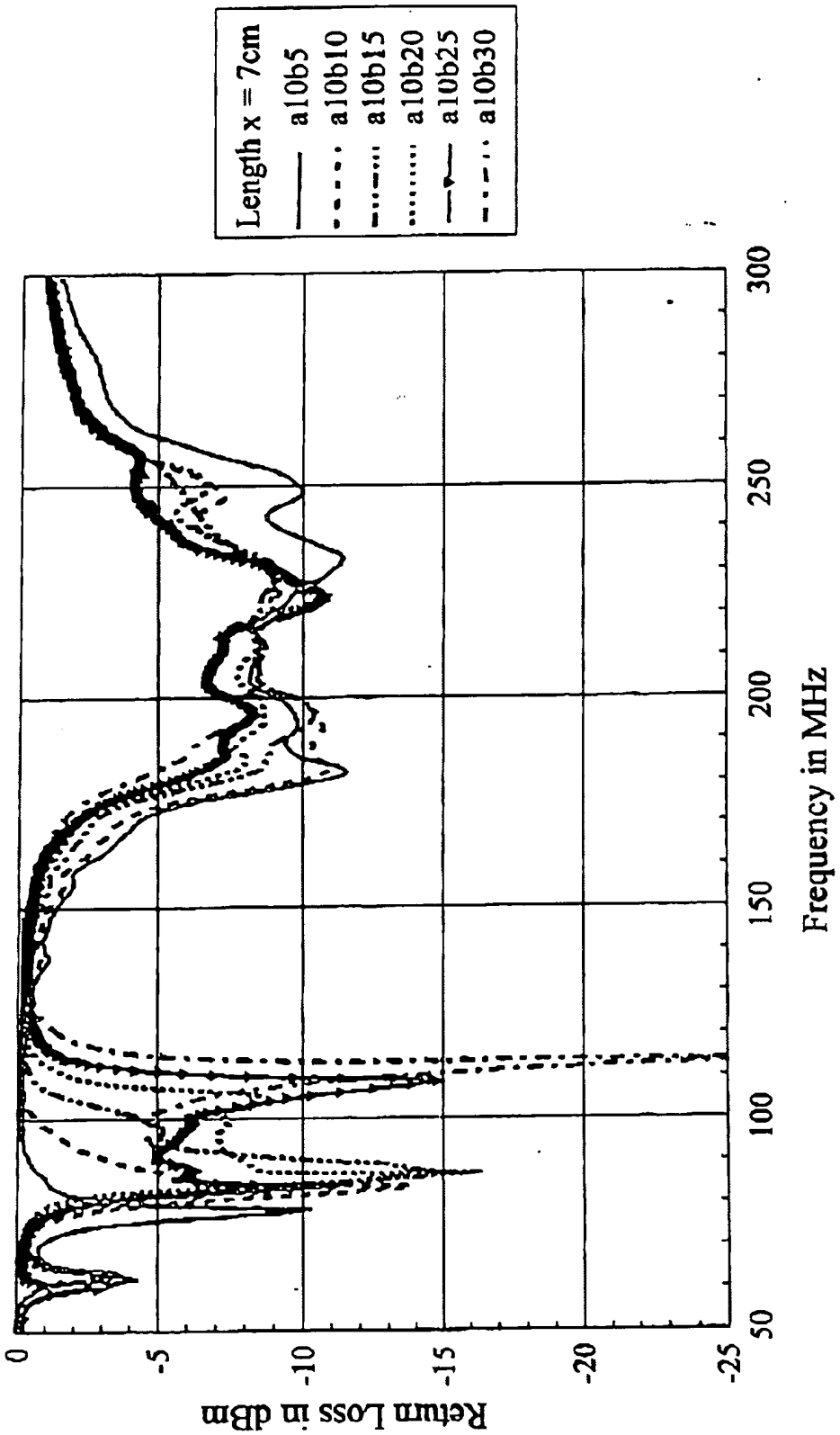

Fig. 14

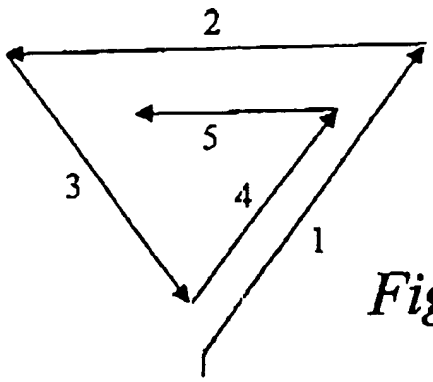

Fig. 18

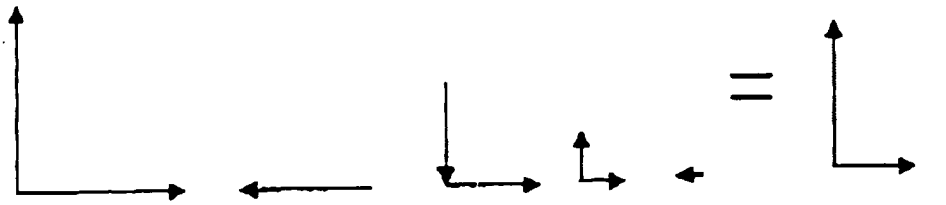

Fig. 19

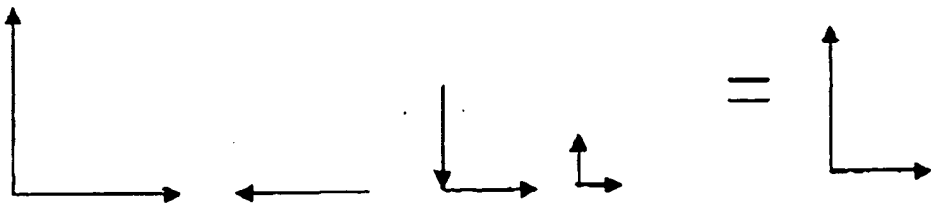

Fig. 20

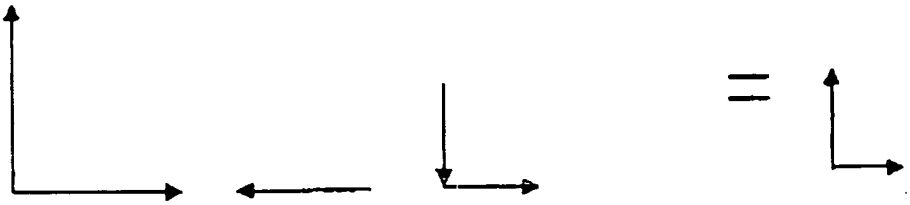

Fig. 21

INTERNATIONAL SEARCH REPORT

Int[illegible]ional Application No
PCT/GB 00/02274

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H01Q1/12 H01Q1/32 H01Q5/00 H01Q9/40 H01Q9/28
H01Q1/38

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H01Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data, PAJ, INSPEC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CHEN J ET AL: "FDTD ANALYSIS OF PRINTED SQUARE SPIRAL ANTENNAS FOR WIRELESS COMMUNICATIONS" IEEE ANTENNAS AND PROPAGATION SOCIETY INTERNATIONAL SYMPOSIUM,US,NEW YORK, NY: IEEE, 14 July 1997 (1997-07-14), pages 1550-1553, XP000790509 ISBN: 0-7803-4179-1 the whole document	1,27
A		2-26
X	WO 97 47054 A (INTERCELL WIRELESS CORP ;EL SHARAWY EL BADAWY AMIEN (US)) 11 December 1997 (1997-12-11) page 4-7; claim 4; figures 2-7	1,27
A		4,5

-/--

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
25 September 2000	04/10/2000

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Ribbe, J

1

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Information on patent family members

Inte[redacted]ional Application No
PCT/GB 00/02274

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 9747054 A	11-12-1997	AU 2748797 A	05-01-1998
US 5363114 A	08-11-1994	NONE	
US 5337063 A	09-08-1994	JP 4321190 A	11-11-1992
		DE 4212808 A	29-10-1992
		GB 2255692 A,B	11-11-1992
		GB 2284324 A,B	31-05-1995
		GB 2284325 A,B	31-05-1995

Form PCT/ISA/210 (patent family annex) (July 1992)

INTERNATIONAL SEARCH REPORT

Inte[redacted]ional Application No
PCT/GB 00/02274

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5 363 114 A (SHOEMAKER KEVIN O) 8 November 1994 (1994-11-08) column 1-6; figures 1,2,9	1,4,5,27
A	US 5 337 063 A (TAKAHIRA KENICHI) 9 August 1994 (1994-08-09) column 3; figure 1	1,4,5,27

Form PCT/ISA/210 (continuation of second sheet) (July 1992)

PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference	FOR FURTHER ACTION	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
MCM/PWJ/21303		
International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/GB00/02274	12/06/2000	10/06/1999
International Patent Classification (IPC) or national classification and IPC H01Q1/12		
Applicant HARADA INDUSTRIES (EUROPE) LIMITED et al.		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 6 sheets, including this cover sheet.

   ☒ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of 2 sheets.

3. This report contains indications relating to the following items:

   - I ☒ Basis of the report
   - II ☐ Priority
   - III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
   - IV ☐ Lack of unity of invention
   - V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations suporting such statement
   - VI ☐ Certain documents cited
   - VII ☒ Certain defects in the international application
   - VIII ☒ Certain observations on the international application

Date of submission of the demand	Date of completion of this report
10/01/2001	16.10.2001
Name and mailing address of the international preliminary examining authority: European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized officer Marot-Lassauzaie, J Telephone No. +49 89 2399 2671

Form PCT/IPEA/409 (cover sheet) (January 1994)

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/GB00/02274

I. Basis of the report

1. With regard to the **elements** of the international application *(Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17))*:
Description, pages:

1-3,5-11	as originally filed			
4	as received on	06/08/2001	with letter of	03/08/2001

Claims, No.:

1-22	as originally filed			
23-28	as received on	06/08/2001	with letter of	03/08/2001

Drawings, sheets:

1/10-10/10	as published

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

   These elements were available or furnished to this Authority in the following language: , which is:

   - ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).
   - ☐ the language of publication of the international application (under Rule 48.3(b)).
   - ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

   - ☐ contained in the international application in written form.
   - ☐ filed together with the international application in computer readable form.
   - ☐ furnished subsequently to this Authority in written form.
   - ☐ furnished subsequently to this Authority in computer readable form.
   - ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
   - ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

   ☐ the description, pages:
   ☐ the claims, Nos.:
   ☐ the drawings, sheets:

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

   (Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)

6. Additional observations, if necessary:

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	1-28
	No:	Claims	
Inventive step (IS)	Yes:	Claims	
	No:	Claims	1-28
Industrial applicability (IA)	Yes:	Claims	1-28
	No:	Claims	

2. Citations and explanations
   see separate sheet

VII. Certain defects in the international application

The following defects in the form or contents of the international application have been noted:
see separate sheet

VIII. Certain observations on the international application

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:
see separate sheet

Re Item VIII

Certain observations on the international application

1. Although claims 1, 4 and 5 have been drafted as separate independent claims, they appear to relate effectively to the same subject-matter and to differ from each other only with regard to the definition of the subject-matter for which protection is sough. The aforementioned claims therefore lack conciseness and do not meet the requirements of Article 6 PCT.

2. Claims 1, 4, 5 and 27 define the antenna and associated manufacturing method in terms of their function ("exhibit resonance in a plurality of frequency bands"). However, the description and drawings convey the impression that this function can only be carried out in a particular way, and no alternative means are envisaged. Hence, the claims are not supported by the description as required by Article 6 PCT.

3. Moreover, because the claims are defined in terms of their function the matter for which protection is sought is not actually defined. The claims attempt to define the subject-matter in terms of the result to be achieved, which merely amounts to a statement of the underlying problem. "Exhibiting resonances in a plurality of frequency bands" is what every antenna designer is looking for, the real invention is to choose a particular geometry of the antenna conductors so that this result is attained.
   The choice of this type of definition implies that it is not possible to determine the full extend of the protection given by the claims (it is not possible to list all designs, for example all polygons, that will exhibit the claimed property).
   The claims should be rewritten in terms of how the effect is to be achieved, i.e. by claiming the particular geometry (orientation and length of conductors, etc... or design formulas) that is necessary for multiple resonance to take place.

4. The applicants may think that their claims should be read as restricted by the examples given in the description. As this is not the case for all national examination authorities, this is not possible for the PCT procedure either. They may also feel that a claim listing the antenna geometry in more details will be more limited. This is true, and actually necessary to ensure that the extent of the

protection given by the claims match the extent of the actual invention. This is not an undue limitation, but a direct consequence of Rule 6.3(a) PCT (see also Item V, point 4 below).

Re Item V

Reasoned statement under Rule 66.2(a)(ii) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Because of the present lack of clarity of the claims, a full examination of novelty and inventive step is not possible. However, no objection is made under section III, because a document so relevant was found that an objection of lack of inventive step can be made.

2. Reference is made to the following document:

   D1: CHEN J ET AL: 'FDTD ANALYSIS OF PRINTED SQUARE SPIRAL ANTENNAS FOR WIRELESS COMMUNICATIONS' IEEE ANTENNAS AND PROPAGATION SOCIETY INTERNATIONAL SYMPOSIUM,US,NEW YORK, NY: IEEE, 14 July 1997 (1997-07-14), pages 1550-1553, XP000790509 ISBN: 0-7803-4179-1

3. It should be prima facie obvious from fig. 1 and 4 of D1, that this document discloses a polygonal spiral antenna with multiple resonance. The polygon used in D1 is a square.
   Classical spiral antenna design encompass spirals with one, two or four branches. The spiral used in D1 is a dual, dipole, spiral. D1 however makes it clear that the particular square shape of its spiral enables a wider bandwidth. It would therefore be straightforward to try this square shape for other classical spiral designs. Trying this square shape for a single spiral would lead to the claimed antenna design, therefore this design lacks inventive step.

4. The claims should be amended to overcome the objections of lack of clarity and inventive step. It appears that the most reasonable way would be to restrict the claims to triangle spirals with a stub antenna, as this appears to be the design

intended from the description (see page 7).

Re Item VII

Certain defects in the international application

1. The features of the claims are not provided with reference signs placed in parentheses (Rule 6.2(b) PCT).

2. To meet the requirements of Rule 6.3 (b) PCT, the independent claims should be properly cast in the two part form, with those features which are part of the prior art (see document D1) being placed in the preamble.

The antenna may be mounted on a substrate for attachment to a window or other surface.

The antenna may comprise a ground plane functionally adjacent the conductor.

Alternatively the antenna may be in combination with a further said antenna, the two antennas being arranged as a dipole.

The invention also provides a window or vehicle body panel or other vehicle fitment comprising an antenna as set forth above.

The window or panel may form a dielectric between the antenna and the ground plane.

In another aspect the invention provides a method of manufacturing an antenna, comprising disposing or defining a single conductor in a polygonal spiral form with a feed connection at or adjacent one end thereof, selecting the spacing between adjacent co-extensive sections of the polygonal spiral form and/or an overall length of the conductor such that the antenna has a plurality of required resonant frequencies. Preferably, the length and angles between successive sections of the polygonal spiral form are selected such that the antenna has a required ratio of horizontal and vertical polarisation.

Preferred features of the present invention will now be described, by way of example only, with reference to the accompany drawings, in which:

Figure 1 illustrates a first embodiment of the antenna of the invention;

Figure 2 illustrates a second embodiment of the antenna of the invention;

Figure 3 is a more detailed view of the antenna of Figure 1;

Figure 4 illustrates a third embodiment of the antenna of the invention;

Figure 5 shows the frequency response of the antenna of Figure 3;

23. An antenna as claimed in any preceding claim, in combination with a further said antenna, the two antennas being arranged as a dipole.

24. An antenna as claimed in any preceding claim, mounted on a substrate for attachment to a window or other surface.

25. A window or vehicle body panel or other vehicle fitment comprising an antenna as claimed in any preceding claim.

26. A window or vehicle body panel or other vehicle fitment as claimed in claim 25, wherein the window or body panel forms a dielectric between the antenna and the ground plane.

27. A method of manufacturing an antenna, comprising disposing or defining a single conductor in a polygonal spiral form with a feed connection at or adjacent one end thereof, and selecting the spacing between adjacent co-extensive sections of the polygonal spiral form and/or an overall length of the conductor such that the antenna has a plurality of required resonant frequencies.

28. A method as claimed in claim 27 comprising selecting the length and angles between successive sections of the polygonal spiral form such that the antenna has a required ratio of horizontal and vertical polarisation.

The antenna may be mounted on a substrate for attachment to a window or other surface.

The antenna may comprise a ground plane functionally adjacent the conductor.

Alternatively the antenna may be in combination with a further said antenna, the two antennas being arranged as a dipole.

The invention also provides a window or vehicle body panel or other vehicle fitment comprising an antenna as set forth above.

The window or panel may form a dielectric between the antenna and the ground plane.

In another aspect the invention provides a method of manufacturing an antenna, comprising disposing or defining a conductor in a polygonal spiral form with a feed connection at or adjacent one end thereof, selecting the spacing between adjacent co-extensive sections of the polygonal spiral form and/or an overall length of the conductor such that the antenna has a plurality of required resonant frequencies. Preferably, the length and angles between successive sections of the polygonal spiral form are selected such that the antenna has a required ratio of horizontal and vertical polarisation.

Preferred features of the present invention will now be described, by way of example only, with reference to the accompany drawings, in which:

Figure 1 illustrates a first embodiment of the antenna of the invention;

Figure 2 illustrates a second embodiment of the antenna of the invention;

Figure 3 is a more detailed view of the antenna of Figure 1;

Figure 4 illustrates a third embodiment of the antenna of the invention;

Figure 5 shows the frequency response of the antenna of Figure 3;

23. An antenna as claimed in any preceding claim, in combination with a further said antenna, the two antennas being arranged as a dipole.

24. An antenna as claimed in any preceding claim, mounted on a substrate for attachment to a window or other surface.

25. A window or vehicle body panel or other vehicle fitment comprising an antenna as claimed in any preceding claim.

26. A window or vehicle body panel or other vehicle fitment as claimed in claim 25, wherein the window or body panel forms a dielectric between the antenna and the ground plane.

27. A method of manufacturing an antenna, comprising disposing or defining a conductor in a polygonal spiral form with a feed connection at or adjacent one end thereof, selecting the spacing between adjacent co-extensive sections of the polygonal spiral form and/or an overall length of the conductor such that the antenna has a plurality of required resonant frequencies.

28. A method as claimed in claim 27 comprising selecting the length and angles between successive sections of the polygonal spiral form such that the antenna has a required ratio of horizontal and vertical polarisation.

PATENT COOPERATION TREATY

From the
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

To:

MOIR, Michael C.
MATHYS & SQUIRE
100 Gray's Inn Road
London WC1X 8AL
GRANDE BRETAGNE

PCT

NOTIFICATION OF TRANSMITTAL OF THE INTERNATIONAL PRELIMINARY EXAMINATION REPORT
(PCT Rule 71.1)

	Date of mailing *(day/month/year)* 16.10.2001
Applicant's or agent's file reference MCM/PWJ/21303	**IMPORTANT NOTIFICATION**

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/GB00/02274	12/06/2000	10/06/1999

Applicant
HARADA INDUSTRIES (EUROPE) LIMITED et al.

1. The applicant is hereby notified that this International Preliminary Examining Authority transmits herewith the international preliminary examination report and its annexes, if any, established on the international application.

2. A copy of the report and its annexes, if any, is being transmitted to the International Bureau for communication to all the elected Offices.

3. Where required by any of the elected Offices, the International Bureau will prepare an English translation of the report (but not of any annexes) and will transmit such translation to those Offices.

4. **REMINDER**

The applicant must enter the national phase before each elected Office by performing certain acts (filing translations and paying national fees) within 30 months from the priority date (or later in some Offices) (Article 39(1)) (see also the reminder sent by the International Bureau with Form PCT/IB/301).

Where a translation of the international application must be furnished to an elected Office, that translation must contain a translation of any annexes to the international preliminary examination report. It is the applicant's responsibility to prepare and furnish such translation directly to each elected Office concerned.

For further details on the applicable time limits and requirements of the elected Offices, see Volume II of the PCT Applicant's Guide.

Name and mailing address of the IPEA/	Authorized officer
European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Touysserkani, T Tel. +49 89 2399-2161

Form PCT/IPEA/416 (July 1992)

PCT

REQUEST

12/6

The undersigned requests that the present international application be processed according to the Patent Cooperation Treaty.

For receiving Office use only

International Application No.

International Filing Date

Name of receiving Office and "PCT International Application"

Applicant's or agent's file reference *(if desired) (12 characters maximum)* MCM/PJ/21303

Box No. I TITLE OF INVENTION

MULTIBAND ANTENNA

Box No. II APPLICANT

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

Harada Industries (Europe) Limited
Bell Heath Way
Woodgate Business Park
Clapgate Lane
Birmingham B32 3BZ
United kingdom

☐ This person is also inventor.

Telephone No.

Facsimile No.

Teleprinter No.

State *(that is, country)* of nationality: UNITED KINGDOM

State *(that is, country)* of residence: UNITED KINGDOM

This person is applicant for the purposes of: ☐ all designated States ☒ all designated States except the United States of America ☐ the United States of America only ☐ the States indicated in the Supplemental Box

Box No. III FURTHER APPLICANT(S) AND/OR (FURTHER) INVENTOR(S)

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

LANGLEY: Richard Jonathan
Harada European Technology Centre
Electronic Engineering Laboratory
University of Kent
Canterbury, Kent CT2 7NT
United Kingdom

This person is:

☐ applicant only

☒ applicant and inventor

☐ inventor only *(If this check-box is marked, do not fill in below.)*

State *(that is,country)* of nationality: UNITED KINGDOM

State *(that is, country)* of residence: UNITED KINGDOM

This person is applicant for the purposes of: ☐ all designated States ☐ all designated States except the United States of America ☒ the United States of America only ☐ the States indicated in the Supplemental Box

☐ Further applicants and/or (further) inventors are indicated on a continuation sheet.

Box No. IV AGENT OR COMMON REPRESENTATIVE; OR ADDRESS FOR CORRESPONDENCE

The person identified below is hereby/has been appointed to act on behalf of the applicant(s) before the competent International Authorities as: ☒ agent ☐ common representative

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)*

MOIR; MICHAEL CHRISTOPHER
MATHYS & SQUIRE
100 Gray's Inn Road
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WC1X 8AL
UNITED KINGDOM

Telephone No.
+44 (0) 20 7 830 0000

Facsimile No.
+44 (0) 20 7 830 0001

Teleprinter No.

☐ **Adress for correspondence:** Mark this check-box where no agent or common representative is/has been appointed and the space above is used instead to indicate a special address to which correspondence should be sent.

Box No.V DESIGNATION OF STATES

The following designations are hereby made under Rule 4.9(a) *(mark the applicable check-boxes; at least one must be marked).*

Regional Patent

- ☒ **AP** **ARIPO Patent:** GH Ghana, GM Gambia, KE Kenya, LS Lesotho, MW Malawi, SD Sudan, SL Sierra Leone, SZ Swaziland, UG Uganda, ZW Zimbabwe, and any other State which is a Contracting State of the Harare Protocol and of the PCT
- ☒ **EA** **Eurasian Patent:** AM Armenia, AZ Azerbaijan, BY Belarus, KG Kyrgyzstan, KZ Kazakhstan, MD Republic of Moldova, RU Russian Federation, TJ Tajikistan, TM Turkmenistan, and any other State which is a Contracting State of the Eurasian Patent Convention and of the PCT
- ☒ **EP** **European Patent:** AT Austria, BE Belgium, CH and LI Switzerland and Liechtenstein, CY Cyprus, DE Germany, DK Denmark, ES Spain, FI Finland, FR France, GB United Kingdom, GR Greece, IE Ireland, IT Italy, LU Luxembourg, MC Monaco, NL Netherlands, PT Portugal, SE Sweden, and any other State which is a Contracting State of the European Patent Convention and of the PCT
- ☒ **OA** **OAPI Patent:** BF Burkina Faso, BJ Benin, CF Central African Republic, CG Congo, CI Côte d'Ivoire, CM Cameroon, GA Gabon, GN Guinea, GW Guinea-Bissau, ML Mali, MR Mauritania, NE Niger, SN Senegal, TD Chad, TG Togo, and any other State which is a member State of OAPI and a Contracting State of the PCT

National Patent *(if other kind of protection or treatment desired, specify on dotted line).*

- ☒ **AE** United Arab Emirates
- ☒ **AL** Albania
- ☒ **AM** Armenia
- ☒ **AT** Austria
- ☒ **AU** Australia
- ☒ **AZ** Azerbaijan
- ☒ **BA** Bosnia and Herzegovina
- ☒ **BB** Barbados
- ☒ **BG** Bulgaria
- ☒ **BR** Brazil
- ☒ **BY** Belarus
- ☒ **CA** Canada
- ☒ **CH and LI** Switzerland and Liechtenstein
- ☒ **CN** China
- ☒ **CU** Cuba
- ☒ **CZ** Czech Republic
- ☒ **DE** Germany
- ☒ **DK** Denmark
- ☒ **EE** Estonia
- ☒ **ES** Spain
- ☒ **FI** Finland
- ☒ **GB** United Kingdom
- ☒ **GD** Grenada
- ☒ **GE** Georgia
- ☒ **GH** Ghana
- ☒ **GM** Gambia
- ☒ **HR** Croatia
- ☒ **HU** Hungary
- ☒ **ID** Indonesia
- ☒ **IL** Israel
- ☒ **IN** India
- ☒ **IS** Iceland
- ☒ **JP** Japan
- ☒ **KE** Kenya
- ☒ **KG** Kyrgyzstan
- ☒ **KP** Democratic People's Republic of Korea
- ☒ **KR** Republic of Korea
- ☒ **KZ** Kazakhstan
- ☒ **LC** Saint Lucia
- ☒ **LK** Sri Lanka
- ☒ **LR** Liberia
- ☒ **LS** Lesotho
- ☒ **LT** Lithuania
- ☒ **LU** Luxembourg
- ☒ **LV** Latvia
- ☒ **MD** Republic of Moldova
- ☒ **MG** Madagascar
- ☒ **MK** The former Yugoslav Republic of Macedonia
- ☒ **MN** Mongolia
- ☒ **MW** Malawi
- ☒ **MX** Mexico
- ☒ **NO** Norway
- ☒ **NZ** New Zealand
- ☒ **PL** Poland
- ☒ **PT** Portugal
- ☒ **RO** Romania
- ☒ **RU** Russian Federation
- ☒ **SD** Sudan
- ☒ **SE** Sweden
- ☒ **SG** Singapore
- ☒ **SI** Slovenia
- ☒ **SK** Slovakia
- ☒ **SL** Sierra Leone
- ☒ **TJ** Tajikistan
- ☒ **TM** Turkmenistan
- ☒ **TR** Turkey
- ☒ **TT** Trinidad and Tobago
- ☒ **UA** Ukraine
- ☒ **UG** Uganda
- ☒ **US** United States of America
  United Republic of Tanzania
- ☒ **UZ** Uzbekistan
- ☒ **VN** Viet Nam
- ☒ **YU** Yugoslavia
- ☒ **ZA** South Africa
- ☒ **ZW** Zimbabwe

Check-boxes reserved for designating States which have become party to the PCT after issuance of this sheet:

- ☒ DZ Algeria
- ☒ AG Antigua & Barbuda
- ☒ MO Mozambique

Precautionary Designation Statement: In addition to the designations made above, the applicant also makes under Rule 4.9(b) all other designations which would be permitted under the PCT except any designation(s) indicated in the Supplemental Box as being excluded from the scope of this statement. The applicant declares that those additional designations are subject to confirmation and that any designation which is not confirmed before the expiration of 15 months from the priority date is to be regarded as withdrawn bythe applicant at the expiration of that time limit. *(Confirmation of a designation consists of the filing of a notice specifying that designation and the payment of the designation and confirmation fees. Confirmation must reach the receiving Office within the 15-month time limit.)*

Supplemental Box *If the Supplemental Box is not used, this sheet should not be included in the request.*

*1. If, in any of the Boxes, **the space is insufficient** to furnish all the information: in such case, write "Continuation of Box No. ..." (indicate the number of the Box) and furnish the information in the same manner as required according to the captions of the Box in which the space was insufficient, in particular:*

*(i) **If more than two persons are involved as applicants and/or inventors** and no "continuation sheet" is available: in such case, write "Continuation of Box No. III" and indicate for each additional person the same type of information as required in Box No. III. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below;*

*(ii) if, in Box No. II or in any of the sub-boxes of Box No. III, the indication **"the States indicated in the Supplemental Box"** is checked: in such case, write "Continuation of Box No. II" or "Continuation of Box No. III" or "Continuation of Boxes No. II and No. III" (as the case may be), indicate the name of the applicant(s) involved and, next to (each) such name, the State(s) (and/or, where applicable, ARIPO, Eurasian, European or OAPI patent) for the purposes of which the named person is applicant;*

*(iii) if, in Box No. II or in any of the sub-boxes of Box No. III, **the inventor or the inventor/applicant is not inventor for the purposes of all designated States or for the purposes of the United States of America**: in such case, write "Continuation of Box No. II" or "Continuation of Box No. III" or "Continuation of Boxes No. II and No. III" (as the case may be), indicate the name of the inventor(s) and, next to (each) such name, the State(s) (and/or, where applicable, ARIPO, Eurasian, European or OAPI patent) for the purposes of which the named person is inventor;*

*(iv) if, in addition to the agent(s) indicated in Box No. IV, there are **further agents**: in such case, write "Continuation of Box No. IV" and indicate for each further agent the same type of information as required in Box No. IV;*

*(v) if, in Box No. V, the name of any State (or OAPI) is accompanied by the indication "**patent of addition**," or "**certificate of addition**," or if, in Box No. V, the name of the United States of America is accompanied by an indication "**continuation**" or "**continuation-in-part**": in such case, write "Continuation of Box No. V" and the name of each State involved (or OAPI), and after the name of each such State (or OAPI), the number of the parent title or parent application and the date of grant of the parent title or filing of the parent application;*

*(vi) if, in Box No. VI, there are **more than three earlier applications whose priority is claimed**: in such case, write "Continuation of Box No. VI" and indicate for each additional earlier application the same type of information as required in Box No. VI;*

*(vii) if, in Box No. VI, **the earlier application is an ARIPO application**: in such case, write "Continuation of Box No. VI", specify the number of the item corresponding to that earlier application and indicate at least one country party to the Paris Convention for the Protection of Industrial Property for which that earlier application was filed.*

*2. If, with regard to the **precautionary designation statement** contained in Box No. V, the applicant wishes to exclude any State(s) from the scope of that statement: in such case, write "Designation(s) excluded from precautionary designation statement" and indicate the name or two-letter code of each State so excluded.*

*3. If the applicant claims, in respect of any designated Office, the benefits of provisions of the national law concerning **non-prejudicial disclosures or exceptions to lack of novelty**: in such case, write "Statement concerning non-prejudicial disclosures or exceptions to lack of novelty" and furnish that statement below.*

Continuation of Box No. IV

RITTER, Stephen David)
GARRATT, Peter Douglas)
COZENS, Paul Dennis)
SCHLICH, George William)
COLMER, Stephen Gary)
KAZI, Ilya)
INGRAM, Brian Victor)
SIMONS, Elisabeth Anne)
BRADLEY, Josephine Mary)
MACLEAN, Martin Robert)

All of: Mathys & Squire
100 Gray's Inn Road
London WC1X 8AL
UNITED KINGDOM

Box No. VI PRIORITY CLAIM ☐ Further priority claims are indicated in the Supplemental Box.

Filing date of earlier application (day/month/year)	Number of earlier application	Where earlier application is: national application: country	regional application:* regional Office	international application: receiving Office
item (1) 10 June 1999	9913526.1	United Kingdom		
item (2)				
item (3)				

☒ The receiving Office is requested to prepare and transmit to the International Bureau a certified copy of the earlier application(s) *(only if the earlier application was filed with the Office which for the purposes of the present international application is the receiving Office)* identified above as item(s): (1)

* *Where the earlier application is an ARIPO application, it is mandatory to indicate in the Supplemental Box at least one country party to the Paris Convention for the Protection of Industrial Property for which that earlier application was filed (Rule 4.10(b)(ii)). See Supplemental Box.*

Box No. VII INTERNATIONAL SEARCHING AUTHORITY

Choice of International Searching Authority (ISA) *(if two or more International Searching Authorities are competent to carry out the international search, indicate the Authority chosen; the two-letter code may be used):*

ISA /

Request to use results of earlier search; reference to that search *(if an earlier search has been carried out by or requested from the International Searching Authority):*

Date *(day/month/year)* Number Country *(or regional Office)*

Box No. VIII CHECK LIST; LANGUAGE OF FILING

This international application contains the following **number of sheets:**

request	: 4
description (excluding sequence listing part)	: 11
claims	: 4
abstract	: 1
drawings	: 10
sequence listing part of description	:
Total number of sheets	: 30

This international application is **accompanied by** the item(s) marked below:

1. ☐ fee calculation sheet
2. ☐ separate signed power of attorney
3. ☐ copy of general power of attorney; reference number, if any:
4. ☐ statement explaining lack of signature
5. ☐ priority document(s) identified in Box No. VI as item(s):
6. ☐ translation of international application into (language):
7. ☐ separate indications concerning deposited microorganism or other biological material
8. ☐ nucleotide and/or amino acid sequence listing in computer readable form
9. ☒ other *(specify)*: 23/77

Figure of the drawings which should accompany the abstract: One

Language of filing of the international application: English

Box No. IX SIGNATURE OF APPLICANT OR AGENT

Next to each signature, indicate the name of the person signing and the capacity in which the person signs (if such capacity is not obvious from reading the request).

.....
MOIR; MICHAEL CHRISTOPHER

Date: 12 June 2000

For receiving Office use only

1. Date of actual receipt of the purported international application:	2. Drawings: ☐ received: ☐ not received:
3. Corrected date of actual receipt due to later but timely received papers or drawings completing the purported international application:	
4. Date of timely receipt of the required corrections under PCT Article 11(2):	
5. International Searching Authority (if two or more are competent): ISA /	6. ☐ Transmittal of search copy delayed until search fee is paid.

For International Bureau use only

Date of receipt of the record copy by the International Bureau: